

**Incorporating Daily Real-Time NESDIS/VIIRS Green Vegetation Fraction Data into the  
NOAA/STRC Unified Environmental Modeling System (UEMS)**

(A supplemental instructions document for EMS/UEMS v3.4.1+ users)

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1. Conventions and notations
  - Filenames are given by *italics*,
  - Executable programs/commands are in **bold type**,
  - Directory path locations are underlined,
  - \$UEMS is the top-level UEMS installation directory (\$EMS for pre-UEMS versions)
  - <domain> is the name of the UEMS run domain of interest, located in \$UEMS/runs
  
2. Brief product background information: In mid-February 2015, NOAA/NESDIS promoted their daily real-time, global 4-km green vegetation fraction (GVF) product to operations on the NOAA Comprehensive Large Array-data Stewardship System server. The NESDIS real-time GVF product is derived using enhanced vegetation index composites from the Suomi-NPP/VIIRS instrument, and represents the fraction of photosynthetically active green vegetation at a given pixel. Additional details on the product can be found in the applicable 2013 AMS and 2015 NWA poster presentations (Vargas et al. 2013,2015; Case et al. 2015). NASA/SPoRT has developed a process for ingesting these data into the EMS/UEMS for use in the Weather Research and Forecasting (WRF) numerical weather prediction model, as outlined below. Use of this product replaces the default coarse-resolution monthly climatology of GVF (or the higher-resolution MODIS-based monthly climatology available in the UEMS). This methodology to incorporate VIIRS GVF into the UEMS/EMS is similar to that used for the SPoRT MODIS GVF product (Case et al. 2014) in a previous supplemental instructions document for the EMS. *Note: global minimum and maximum arrays are stored in the daily VIIRS GVF product at t-3 months and t+3 months of the current month, in order to scale additional parameters at WRF model run-time that depend on input GVF, such as surface albedo and emissivity.*
  
3. Assumptions: The instructions outlined below assume that the user already has created a domain that is being used to generate WRF model simulations. It is also assumed that the end-user has a working knowledge of the UEMS/EMS and can navigate through the UEMS directories, configure a modeling domain, and set up various run-time and post-processing options. The only aspect of an UEMS domain that is being modified is the static netcdf file(s) that define the input fields that do not vary during a WRF model simulation (e.g., *geo\_em.d01.nc*, *geo\_nmm.d01.nc*). These files reside in the static/ sub-directory for any given UEMS run domain (e.g., \$UEMS/runs/<domain>/static/).

### Specific instructions:

4. Configure UEMS to accept daily NESDIS/VIIRS GVF files
  - a. Change directory to \$UEMS/data/geog and create a new directory called greenfrac\_viirsgvf:
    - i. **cd \$UEMS/data/geog**
    - ii. **mkdir greenfrac\_viirsgvf**
  - b. Create or acquire the file *index* from NASA/SPoRT and place it in the \$UEMS/data/geog/greenfrac\_viirsgvf directory, with the following contents:

```
type=continuous
projection=regular_ll
dx=0.036
dy=0.036
known_x=1.0
known_y=1.0
known_lat=-89.982
known_lon=-179.982
wordsize=1
missing_value=0.
tile_x=10000
tile_y=5000
tile_z=12
tile_bdr=0
scale_factor=0.01
units="fraction"
description="Monthly green fraction"
```

The index file is available at: <ftp://geo.msfc.nasa.gov/SPoRT/modeling/wrf/uems/VIIRSGVF/index>

- c. Modify the appropriate GEOGRID.TBL file, based on the dynamical core being run
  - i. Make a backup copy of the *GEOGRID.TBL.ARW* or *GEOGRID.TBL.NMM* file, located in \$UEMS/data/tables/wps
  - ii. Edit *GEOGRID.TBL.ARW* or *GEOGRID.TBL.NMM* to modify the GREENFRAC block:

```
=====
name=GREENFRAC
priority=1
  dest_type=continuous
  interp_option=viirsgvf:four_pt+average_4pt+average_16pt+search      (← add this line)
  interp_option=modis_fpar:four_pt+average_4pt+average_16pt+search
  interp_option=default:four_pt+average_4pt+average_16pt+search
  z_dim_name=month
  masked = water
  fill_missing = 0.
  rel_path=viirsgvf:greenfrac_viirsgvf/                                (← add this line)
  rel_path=modis_fpar:greenfrac_fpar_modis/
  rel_path=default:greenfrac/
=====
```

5. Acquire daily VIIRS GVF data file
  - a. New data are typically posted by 1200 UTC each day at  
<ftp://geo.msfc.nasa.gov/SPoRT/modeling/viirsgvf/global/>
  - b. The most recent file is named *00001-10000.00001-05000.bz2* and will typically be between 60–95 MB in size.
  - c. Acquire file via wget:
    - i. **cd \$UEMS/data/geog/greenfrac\_viirsgvf**
    - ii. **wget <ftp://geo.msfc.nasa.gov/SPoRT/modeling/viirsgvf/global/00001-10000.00001-05000.bz2>**
  - d. Uncompress newly acquired SPoRT GVF file
    - i. **cd \$UEMS/data/geog/greenfrac\_viirsgvf**
    - ii. **bzip2 -d 00001-10000.00001-05000.bz2**
    - iii. The file will uncompress to a size of 600 MB
  
6. Backup/copy the original static netcdf geo file to a unique directory and filename for comparing the original GVF monthly climatological data to the new VIIRS GVF daily data.
  - a. **cd \$UEMS/runs/<domain>/static**
  - b. **cp geo\_em.d01.nc <NEW\_USER\_DIRECTORY>/geo\_em.d01.nc.CLIMOGVF**
  - c. Re-do step (b) for each nested domain as well (i.e., d02, d03, etc.).
  
7. Do a one-time edit of the file *\$UEMS/runs/<domain>/static/namelist.wps*
  - a. Backup the original *namelist.wps* file
  - b. Modify the “geog\_data\_res” entry to include “viirsgvf+” before the data resolution
    - i. Working example #1: change “5m” to “viirsgvf+5m”
    - ii. Working example #2: change “modis\_lakes+modis\_30s+30s” to “modis\_lakes+modis\_30s+viirsgvf+30s”
  
8. Re-localize your domain(s) to incorporate the new VIIRS GVF data using existing UEMS utilities
  - a. **cd \$UEMS/runs/<domain>**
  - b. **ems\_domain --nogres --localize <domain>**
  - c. The above command establishes the VIIRS GVF as the new static GVF for use on the run domain for future WRF model runs.
  - d. Note that the **ems\_domain** command should be re-run each time a new VIIRS GVF data set is acquired.

9. Template script for data acquisition and re-localization: SPoRT recommends that the data acquisition, file de-compression, and re-localization of any domains be run daily in a simple script that is invoked through the workstation's cron scheduler. A template `-csh` script and crontab entry is provided in Appendix A to be modified for the end-user's system, and is available at: [http://geo.msfc.nasa.gov/SPoRT/modeling/wrf/uems/VIIRSGVF/acquireVIIRSGVF\\_wget.csh](http://geo.msfc.nasa.gov/SPoRT/modeling/wrf/uems/VIIRSGVF/acquireVIIRSGVF_wget.csh)
10. Compare climatology and VIIRS GVF: The **ncview** utility that comes with the UEMS installation can be used as a quick "sanity check" to validate that the higher-resolution VIIRS GVF has, in fact, replaced the default [coarse-res] GVF monthly climatology. As stated in step (6), it is recommended that the original *geo\_em.d01.nc* [or *geo\_nmm.d01.nc* for pre-UEMS versions] files be copied into a separate directory and filename (for all nested domains as well), since the UEMS deletes the geo files residing in the `$UEMS/runs/<domain>/static/` sub-directory when re-localizing. Once you have run **ems\_domain** with the new VIIRS GVF, and have two separate geo files for the original and re-localization in a separate directory outside of the UEMS installation, then one can run **ncview** to display the GREENFRAC fields for comparison. As a working example, let's say that the original geo file was copied to the filename *geo\_em.d01.nc.CLIMOGVF* and the VIIRS-localized geo file was copied to *geo\_em.d01.nc.VIIRSGVF*. The commands to run are simply:

```
ncview geo_em.d01.nc.CLIMOGVF &  
ncview geo_em.d01.nc.VIIRSGVF &
```

For each instance of **ncview**, a window will pop up that shows the variables available in the geo netcdf file, as shown in Figure 1.

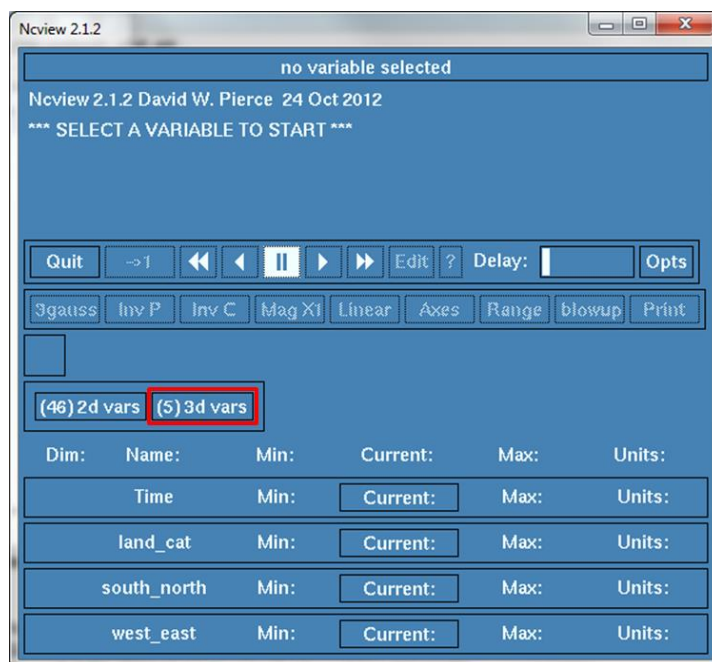


Figure 1. Pop-up window when running **ncview** on a given geo netcdf file generated by the UEMS. The red box indicates the 3d variables under which the GREENFRAC field resides.

To view the GREENFRAC data in the ncview window, hold down the left mouse button on the “(5) 3d vars” box, and scroll down to “GREENFRAC” before releasing the left mouse button. A new window will pop up displaying the first entry in the GREENFRAC field. Additionally, the native window will update to reflect the dimensions of the GREENFRAC 3D variable, as illustrated in Figure 2. One can step through the 12 monthly displays of the GVF climatology by clicking the left mouse button on the number that intersects the “month” row and “Current:” column on the ncview navigation window (Figure 2; left).

The original GREENFRAC has 12 unique, coarse-res fields representing each month of the GVF climatology. The new GREENFRAC based on VIIRS GVF also has 12 entries, but 10 of the 12 entries are all identical with the same data from the daily VIIRS GVF dataset that was used to re-localize the domain. The exception is for the fields at 3 months prior to and following the valid model initialization month. In t-3 months, a global minimum GREENFRAC is stored, along with a global maximum field at t+3 months. The global minimum and maximum fields are necessary so that other variables dependent on GREENFRAC (e.g., surface albedo and emissivity) are properly scaled according to land-use look-up table definitions.

An example GREENFRAC field for the VIIRS GVF dataset valid on 21 May 2015 is shown over the same south-central Asia domain, depicting the real-time VIIRS GVF GREENFRAC. What is immediately apparent is the marked difference in resolution between the original climatology and VIIRS GVF datasets. This distinction should be a sufficient indication that the ingestion of VIIRS GVF data is working correctly in the UEMS re-localization. An additional check to ensure that the VIIRS GVF data are reasonable for the time of year is to visualize the monthly field in the climatology within **ncview** closest to the day of the VIIRS GVF, and compare the range of values between the monthly climatology and VIIRS GVF field. Keep in mind that the VIIRS GVF can and should substantially differ from the climatology at times, due to resolution differences and anomalous weather/climate regimes that affect vegetation health and coverage.

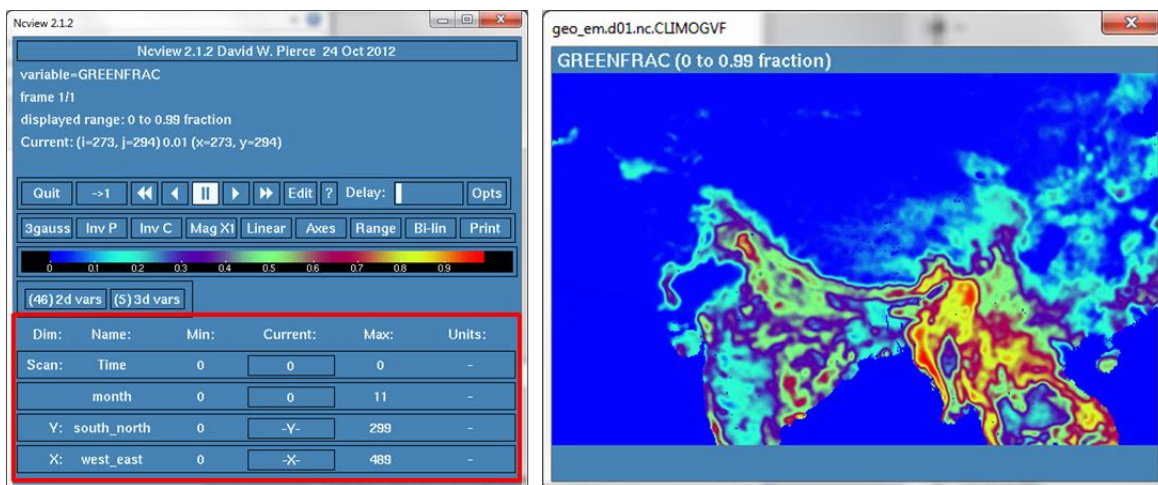


Figure 2. The original ncview window reflecting the dimensions of the GREENFRAC variable (highlighted by the red box; left), and the first GREENFRAC data entry in the new pop-up window (i.e., January; right) as shown for a south-central Asia sample domain, using the original monthly climatology data.

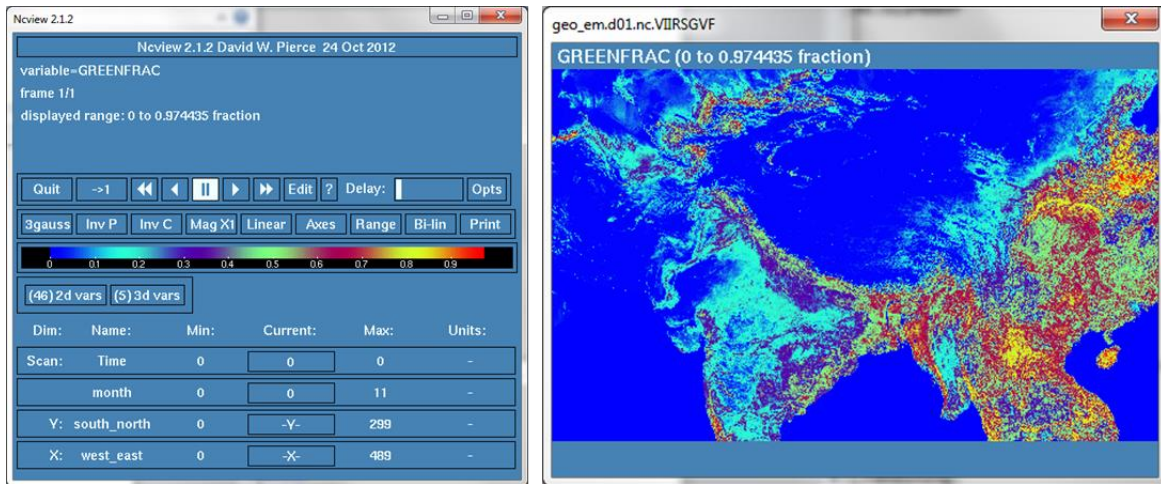


Figure 3. The ncview navigation window reflecting the dimensions of the GREENFRAC variable (left), and the GREENFRAC data entry in the pop-up window for the daily VIIRS GVF dataset valid 21 May 2015, as shown for a south-central Asia sample domain.

#### 11. List of acronyms and abbreviations

- ARW = Advanced Research WRF
- EMS = Environmental Modeling System
- GREENFRAC / GVF = Green Vegetation Fraction
- MODIS = Moderate Resolution Imaging Spectroradiometer
- NESDIS = National Environmental Satellite, Data, and Information Service
- NMM = Non-hydrostatic Mesoscale Model
- SPoRT = Short-term Prediction Research and Transition Center
- UEMS = Unified Environmental Modeling System
- VIIRS = Visible Infrared Imaging Radiometer Suite
- WRF = Weather Research and Forecasting model

#### References:

Case, J. L., F. J. LaFontaine, J. R. Bell, G. J. Jedlovec, S. V. Kumar, and C. D. Peters-Lidard, 2014: A real-time MODIS vegetation product for land surface and numerical weather prediction models. *Trans. Geosci. Remote Sens.*, **52(3)**, 1772-1786.

Case, J. L., Z. Jiang, and M. Vargas, 2015: Real-time Suomi-NPP green vegetation fraction for improving numerical weather prediction and situational awareness. Preprints, 40<sup>th</sup> National Weather Association annual meeting, Oklahoma City, OK, Natl. Wea. Assoc., AP-10. [Available online at [www.nwas.org/meetings/nwa2015/extended-abstracts/2716.pdf](http://www.nwas.org/meetings/nwa2015/extended-abstracts/2716.pdf)]

Vargas, M., Z. Jiang, J. Ju, and I. A. Csiszar, 2013: EVI based green vegetation fraction derived from Suomi NPP-VIIRS. Preprints, *Ninth Symp. Future Operational Env. Sat. Systems*, Austin, TX, Amer. Meteor. Soc., P689. [Available online at <https://ams.confex.com/ams/93Annual/webprogram/Paper224076.html>]

Vargas, M., Z. Jiang, J. Ju, and I. A. Csiszar, 2015: Real-time daily rolling weekly Green Vegetation Fraction (GVF) derived from the Visible Imaging Radiometer Suite (VIIRS) sensor onboard the SNPP satellite. Preprints, *20th Conf. Satellite Meteorology and Oceanography*, Phoenix, AZ, Amer. Meteor. Soc., P210. [Available online at <https://ams.confex.com/ams/95Annual/webprogram/Paper259494.html>]

## Appendix A: Sample c-shell script and crontab entry for acquiring VIIRS GVF data

```
#!/bin/csh
# This sample script acquires the daily NESDIS/VIIRS GVF file, places it in the correct local directory,
# uncompresses the file, and re-runs the ems_domain localization script.
#
# extra local flag to support local data availability.
# usually set to "n"
set local = "n"
set domlist = "domain1 domain2 domain3" (← Modify this line)

# Define directories:
setenv EMS /my/uems/install/directory/uems (← Modify this line)
setenv GVFDIR $EMS/data/geog/greenfrac_viirsgvf
source $EMS/etc/EMS.cshrc

# Optionally input YYYYMMDD argument; otherwise use most recent data (yesterday)
if ($#argv == 1) then
    set yyyymmdd = $1
    set gvffile = "00001-10000.00001-05000.${yyyymmdd}"
else
    set yyyymmdd = `date -u +%Y%m%d`
    set yyyymmdd = `date -u +%Y%m%d -d "${yyyymmdd}-1 days"`
    set gvffile = "00001-10000.00001-05000.${yyyymmdd}"
endif

# Change directory to where VIIRS GVF data reside
cd $GVFDIR

if ($local != "y") then
    echo "Downloading viirsgvf file ${gvffile}.bz2"
    # direct wget of file from SPoRT's server.
    wget http://geo.msfc.nasa.gov/SPoRT/modeling/viirsgvf/global/\${gvffile}.bz2
endif

# set and uncompress newly acquired VIIRS GVF file
echo "Un-compressing VIIRS GVF file ${gvffile}.bz2"
cp -p ${gvffile}.bz2 00001-10000.00001-05000.bz2
bzip2 -df 00001-10000.00001-05000.bz2

# Run ems_domain to re-localize domain(s) of interest
# Repeat for all domains of interest in the $EMS/runs directory
# as defined in the domlist variable below (space separated).

foreach dom ( ${domlist} )
    echo "Localizing domain ${dom}"
    cd $EMS/runs/${dom}
    ems_domain --nogres --localize ${dom}
end

exit
```

Sample crontab entry to run at 1200 UTC daily:

```
0 12 * * * Path-to-acquireScript/acquireGVF.csh >> acquireGVF.log 2>&1 (← Customize Path)
```